5

Conclusions and Recommendations

The first five conclusions from the mid-course assessment are based on the trends in accident rates discussed in Sections 2 and 3, plus the portfolio review of projects related to the risks from Section 4. The final conclusion and recommendation relate to the entire portfolio, including programs that either provide indirect support to the specific accident reduction objectives or support other objectives of the *National Aviation Weather Program Strategic Plan*.

Accident Risk Reduction Actions

The NTSB weather factor citations for Part 91 aircraft (general aviation) show strong downward trends. If the trends hold, the citation rates for fatal weather-related accidents will meet or exceed the benchmark goal of an 80 percent reduction for this aviation category. The reduction goal can even be met within most of the weather hazard categories. The portfolio analysis indicates that a combination of factors has contributed to this good news, including products and services from the National Weather Service Modernization, aviation-specific products and systems from R&D sponsored by the FAA's Aviation Weather Research Program, and better information dissemination systems and services. Particularly important for general aviation has been the knowledge pilots have gained, through education and training opportunities, in how to use the information that these technological advances are making available.

The aim should be to provide every general aviation pilot with knowledge of all weather hazards the pilot is likely to encounter…

Conclusion 1. The partnerships through which aviation and weather associations, the aviation industry, and federal agencies have provided education, training, and outreach to the general aviation community have made a strong beginning in reducing the risks of weather-related accidents in the Part 91 aircraft regulatory category. The ambitious goal of an 80 percent reduction in the fatal accident rate for general aviation appears attainable by 2006 if these efforts can be expanded to reach every general aviation pilot. The general aviation community will also need to know about new products and services that are becoming available, such as those resulting from university-based R&D. The development and implementation programs for these new products and services must be sustained, despite fiscal constraints and tight budgets.

Recommendation 1. The partnerships for education, training, and outreach should be expanded to include more collaboration among entities offering courses and materials. The aim should be to provide every general aviation pilot with knowledge of all weather hazards that the pilot is likely to encounter, together with the information and advisory services to deal with them safely. To sustain the accident reduction trends, these education and outreach efforts must keep pilots informed about the new products and services emerging from R&D to the implementation phase.

The accident trends for Part 135 aviation differ from the trends for both the general aviation community regulated under FAR Part 91 and the major commercial carriers regulated under FAR Part 121. Many of the data series for annual weather factor citation rates, even when aggregated into hazard categories, display considerable year-to-year variability. Nonetheless, only in two categories do the linear regression trends indicate that an 80 percent reduction in fatal accident rates will be achieved

by 2006. A particular concern is that Part 135 trends are flat or even increasing for several weather hazard categories. The data series for all weather-related accidents in each hazard category confirm the indications that aircraft regulated under Part 135 are not experiencing the risk reductions occurring for aircraft under Parts 91 and 121. A number of factors appear to make this aircraft category different, although the actual contribution of each factor cannot be assessed from the data available for this report.

The technology exists to lower weather-related risks for Part 135 operations… A more detailed analysis is needed to assess the impact of weather hazards on this aviation community.

Conclusion 2. Part 135 aviation is constrained by factors that distinguish it from either general aviation or major commercial carriers. The range of operations and types of services offered in this category vary widely and include some that are inherently more hazardous than general aviation or commercial air carrier flights. Early results from the Alaskan Region Capstone demonstration, part of the FAA's Safe Flight 21 program, indicate that the technology exists to lower weather-related accident risks for at least some Part 135 operations. Unfortunately, the current deployment schedule for Safe Flight 21 will not provide weather information coverage across most of the National Airspace System until the 2007–12 time frame. A more detailed analysis of weather-related accidents involving Part 135 aircraft will be needed to determine how different segments of this diverse category are affected by various weather hazards and what actions could be taken to lessen the risks and reduce accident rates.

Recommendation 2. A more detailed analysis, probably employing a case analysis approach, should be conducted to assess the impact of weather hazards on specific segments of the aviation community regulated under Part 135. As an interim measure, a special effort should be made to ensure that both pilots and owners of Part 135 aircraft are aware of the weather information infrastructure and services available to them.

- Prior to deployment of Flight Information Services–Broadcast under the Safe Flight 21 program, available information sources and services, such as the Aviation Digital Data Service and the Flight Information Services Data Link, can be emphasized in the outreach program.
- As the Flight Information Services–Broadcast becomes available via the Safe Flight 21 Universal Access Transceiver communications uplink, training in this information service should be emphasized.

Turbulence and convection hazards continue to be cited as factors in the majority of weather-related accidents involving major air carriers (Part 121 aviation). Fortunately, these accidents now rarely result in fatalities. Fatal accidents involving this weather hazard category are decreasing for Part 91 and Part 135 aviation, but the rates for both fatal and total accidents make this weather hazard category a continuing concern.

Conclusion 3. No single sensor system or forecast improvement will address the entire range of conditions, both en route and in the terminal area, that produce turbulence and convection hazards. Nevertheless, a sustained effort can put new technology in place, assess its effectiveness, and ensure full implementation of products and services with proven efficacy. A number of programs that are likely to improve detection, forecast, and warnings about these hazards are in or nearing the implementation stage.

Recommendation 3. Investment should continue in R&D and implementation on projects that will contribute to timely observations, forecasts, and warnings of turbulence and convection phenomena, both en route and near the terminal area.

High density altitude can be addressed if the pilot has the correct information and the tools and training to use it.

For the period reviewed for this assessment (1996 through 2001), high density altitude has been the most frequently cited factor in the category of temperature and lift hazards for general aviation and Part 135 carriers. Multiple factors of altitude (elevation of the takeoff or landing site), temperature, and humidity interact to complicate a pilot's calculation of the correct density altitude. The pilot needs accurate data on conditions (temperature and humidity) for the location (elevation) and time at which the aircraft will be in a situation where density altitude could ad-

versely affect a flight maneuver. The pilot must then consider the performance consequences for a specific airframe, engine characteristics, and load (weight and trim).

Conclusion 4. The hazard of high density altitude can be addressed, if the pilot has accurate observations or forecasts and a decision support tool that receives this information and combines it with the specifications and running condition of the aircraft. The pilot must also have the training to understand the implications of advice or guidance provided by this decision support capability.

The aviation R&D efforts undertaken jointly by partnerships of federal agencies, industry, universities, and associations have produced substantial returns on the federal investment.

Recommendation 4. A review should be undertaken of the circumstances contributing to aviation accidents in which the National Transportation Safety Board has cited high density altitude as a factor. This review should assess the tools currently available to Part 91 and Part 135 pilots to assess density altitude and related aircraft performance parameters, as well as the weather information products, decision support capabilities, or education and training resources that could be provided or improved to reduce the risk from this weather hazard.

The strong downward trends for fatal and total weather-related general aviation accidents in most weather hazard categories, as well as the continued progress in reducing weather-related accidents involving the major carriers (Part 121 aviation), provide evidence that the national aviation weather initiatives are producing results. However, the fatal accident trends have not yet achieved the 80 percent reduction goal set in 1997. Most of the weather factors that continue to cause fatal accidents can be further ameliorated by programs and projects that are ready for implementation now or will be in the next few years. Examples discussed in this report include fog and low ceiling, in the ceiling and visibility service area, and terminal area winds.

Conclusion 5. Curtailment or delays in implementation of useful new products, services, and systems could jeopardize achievements in accident reduction that seem within reach if we stay the course. Continued support is essential for these efforts, which are nearing the point of producing real returns and achieving a national safety priority.

Recommendation 5. Investment should be sustained for aviation weather projects and programs whose results are likely to further reduce the risks from weather hazards that continue to be cited in aviation accidents. All the partners whose joint efforts in the past have made possible the progress documented in this assessment must continue their commitments and strengthen their collaborations.

The benefits of aviation weather R&D are passed on to passengers and consumers as increased safety and improved efficiency and access. Photo courtesy Wings of Alaska Airlines, © Fred Hirschmann.

Conclusion on the General Status of the Portfolio

Many of the projects listed in Table 10 are now, or soon will be, contributing to the safety and efficiency of the National Airspace System. The highlights from the five product areas—weather product development; weather product dissemination; education, training, and outreach; cockpit displays; and decision support systems and capabilities—illustrate how projects and initiatives in each area complement and leverage one another. New weather information products must be disseminated to end users who have been trained to use them correctly. As the information available increases, well-designed human-machine interfaces are necessary to convey the right information at the right time without distraction or confusion. Decision support capabilities and systems can integrate and interpret these multiple data items into a coherent "situational awareness" for the user.

The President's Council of Advisors on Science and Technology issued a report in October 2002 on "Assessing the U.S. R&D Investment." The council's third recommendation was that the Office of Science and Technology Policy, in cooperation with the appropriate agencies and organizations, "should assess and analyze the adequacy of federal R&D investments in light of national interests, international competition, and human resource needs." The composite structure of aviation weather R&D efforts, undertaken jointly by partnerships among federal agencies, industry, universities, and aviation-interested associations, meets this performance test of producing substantial returns on the federal R&D investment.

Curtailment or delays in implementing useful products, services and systems could jeopardize accident reductions that seem within reach if we stay the course.

Conclusion 6. The combined and complementary effects of implemented aviation weather R&D have produced substantial and continuing benefits for the entire aviation industry. Those benefits are passed on to passengers and consumers as increased safety during air travel and improved efficiency and access in the air transport of passengers and cargo. To continue the promising trends—and to overcome the remaining challenges—in reducing weather-related aviation risks identified in this assessment will require sustaining the R&D and implementation programs in progress.

Recommendation 6. The investments in national aviation weather programs and initiatives should be supported and promoted as an effective investment in the nation's future.

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Appendix A

NTSB Weather Factor Citation Data 1995–2001

Note: The citation frequencies in these tables were calculated using the annual estimates of flight-hours (Parts 91 and 135) or departures (Part 121) from Table 1. These estimates are shown at the bottom of each table.

TABLE A-1. Part 91 (general aviation) weather factor trend analysis: factor citations, all weather-related accidents

Hazard category and weather factor	1995	1996	1997	1998	1999	2000	2001	Total
A. Restricted visibility and ceiling hazards								
Below approach/landing minimums	3	10	3		2	5	1	24
Clouds	16	16	17	22	16	12	4	103
Fog	45	37	35	29	16	25	16	203
Haze/smoke	7	3	6	4	1	2	3	26
Low ceiling	59	45	52	41	34	36	19	286
Obscuration	8	7	8	12	10	8	3	56
Whiteout	2			1	1	1	3	8
Total hazard category citations	140	118	121	109	80	89	49	706
Frequency per 100,000 flight-hours[a]	0.56	0.47	0.47	0.43	0.27	0.31	0.18	0.38
2006 goal	0.10							
2006 projection	0.00							
B. Precipitation (non-icing) hazards								
Rain	11	7	13	9	9	5	6	60
Snow	17	11	9	6	7	17	8	75
Drizzle/mist	1	4	1	3	3	3	3	18
Total hazard category citations	29	22	23	18	19	25	17	153
Frequency per 100,000 flight-hours[a]	0.116	0.088	0.090	0.071	0.064	0.086	0.062	0.082
2006 goal	0.020							
2006 projection	0.027							
C. Icing conditions								
Icing conditions	25	18	11	9	13	9	3	88
Ice fog							1	1
Freezing rain	1		1	2		2	1	7
Carburetor icing conditions	28	17	24	26	18	18	17	148
Total hazard category citations	54	35	36	37	31	29	22	244
Frequency per 100,000 flight-hours[a]	0.217	0.141	0.141	0.145	0.104	0.100	0.080	0.130
2006 goal	0.036							
2006 projection	0.000							
D. Turbulence and convection hazards								
Turbulence (thunderstorms)	1	5	3	2		1		12
Thunderstorm	13	12	3	3	7	5	3	46
Thunderstorm (outflow)	3	1	2				1	7
Microburst/dry	1			1	1		1	4
Microburst/wet	1							1
Updraft				1	1	1	1	4
Downdraft	30	22	12	16	23	21	11	135
Gusts	74	105	87	75	74	51	62	528
Wind shear	8	9	1	6	8	9	5	46
Dust devil/whirlwind	3	5	2	1	9	4	6	30
Variable wind	6	11	5	10	9	9	12	62
Sudden wind shift	11	6	8	12	12	6	6	61
Mountain wave	2	1	2	3	1	1		10
Turbulence	13	10	7	9	13	4	3	59
Turbulence, clear air		3	1	2		1		7
Turbulence in clouds		1	1	2	1	2		7
Turbulence (terrain induced)	6	5	5	6	1	5	1	29
Total hazard category citations	172	196	139	149	160	120	112	1,048
Frequency per 100,000 flight-hours[a]	0.691	0.788	0.543	0.584	0.538	0.413	0.408	0.560
2006 goal	0.15							
2006 projection	0.11							

(continued)

TABLE A-1. Part 91 (general aviation) weather factor trend analysis: factor citations, all weather-related accidents (continued)

Hazard category and weather factor	1995	1996	1997	1998	1999	2000	2001	Total
E. Temperature and lift hazards								
Temperature inversion							1	1
High density altitude	25	36	33	37	48	29	15	223
Temperature, high	3	4	5		1	1	1	15
Temperature, low	2				1	1		4
Thermal lift		1	1				3	5
No thermal lift	4	4	2	4	5	2	2	23
Total hazard category citations	34	45	41	41	55	33	22	271
Frequency per 100,000 flight-hours[a]	0.137	0.181	0.160	0.161	0.185	0.114	0.080	0.14
2006 goal	0.032							
2006 projection	0.066							
F. En route and terminal winds								
Unfavorable wind	20	14	17	7	6	7	1	72
Crosswind	90	123	111	87	78	80	77	646
Tail wind	50	36	36	46	46	52	41	307
High wind	18	36	17	19	12	14	20	136
Total hazard category citations	178	209	181	159	142	153	139	1,161
Frequency per 100,000 flight-hours[a]	0.71	0.84	0.71	0.62	0.48	0.53	0.51	0.62
2006 goal	0.16							
2006 projection	0.20							
G. Electrical hazards								
Lightning	1				1	1		3
Static discharge		1						1
Total hazard category citations	1	1	0	0	1	1	0	4
Frequency per 100,000 flight-hours[a]	0.004	0.004	0.000	0.000	0.003	0.003	0.000	0.002
2006 goal	0.0008							
2006 projection	0.0000							
H. Airborne solids hazards								
Sand/dust storm	1							1
Hail		2			1			3
Total hazard category citations	1	2	0	0	1	0	0	4
Frequency per 100,000 flight-hours[a]	0.004	0.008	0.000	0.000	0.003	0.000	0.000	0.002
2006 goal	0.001							
2006 projection	0.000							

[a]FAA estimated flight-hours per year:

1995	24,906,000
1996	24,881,000
1997	25,591,000
1998	25,518,000
1999	29,713,000
2000	29,057,000
2001	27,451,000

TABLE A-2. Part 91 (general aviation) weather factor trend analysis: factor citations, weather-related fatal accidents

Hazard category and weather factor	1995	1996	1997	1998	1999	2000	2001	Total
A. Restricted visibility and ceiling hazards								
Below approach/landing minimums	2	4			1	4		11
Clouds	14	11		16	11	10	3	65
Fog	34	30	22	22	9	15	11	143
Haze/smoke	3		3	2		1	2	11
Low ceiling	47	34	36	33	23	27	13	213
Obscuration	5	5	8	8	8	6	3	43
Whiteout						1		1
Total hazard category citations	105	84	69	81	52	64	32	487
Frequency per 100,000 flight-hours[a]	0.42	0.34	0.27	0.32	0.18	0.22	0.12	0.260
2006 goal	0.08							
2006 projection	0.00							
B. Precipitation (non-icing) hazards								
Rain	3	6	9	7	5	2	3	35
Snow	13	8	6	5	2	9	4	47
Drizzle/mist	1	2	1	2	3	2	2	13
Total hazard category citations	17	16	16	14	10	13	9	95
Frequency per 100,000 flight-hours[a]	0.068	0.064	0.063	0.055	0.034	0.045	0.033	0.051
2006 goal	0.013							
2006 projection	0.002							
C. Icing conditions								
Icing conditions	14	11	4	5	6	4		44
Ice fog							1	1
Freezing rain	1			2		1		4
Carburetor icing conditions	1	1	4	1		2	1	10
Total hazard category citations	16	12	8	8	6	7	2	59
Frequency per 100,000 flight-hours[a]	0.064	0.048	0.031	0.031	0.020	0.024	0.007	0.032
2006 goal	0.011							
2006 projection	0.000							
D. Turbulence and convection hazards								
Turbulence (thunderstorms)	1	4	2	2		1		10
Thunderstorm	8	8	3	2	6	3	3	33
Thunderstorm (outflow)	1							1
Microburst/dry	0							0
Microburst/wet	1							1
Updraft								0
Downdraft	3	2	1	1	2	1	2	12
Gusts	5	9	9	7	2	3	3	38
Wind shear		1		2		4		7
Dust devil/whirlwind	1							1
Variable wind					1			1
Sudden wind shift				1		1		2
Mountain wave	1	1	2	1	1			6
Turbulence	4	3	4	3	4	2	1	21
Turbulence, clear air		1		1				2
Turbulence in clouds		1		2	1	1		5
Turbulence (terrain induced)	3	3	2	4	1	1		14
Total hazard category citations	28	33	23	26	18	17	9	154
Frequency per 100,000 flight-hours[a]	0.11	0.13	0.090	0.102	0.061	0.059	0.03	0.082
2006 goal	0.02							
2006 projection	0.00							

(continued)

TABLE A-2. Part 91 (general aviation) weather factor trend analysis: factor citations, weather-related fatal accidents (continued)

Hazard category and weather factor	1995	1996	1997	1998	1999	2000	2001	Total
E. Temperature and lift hazards								
Temperature inversion								0
High density altitude	3	9	10	8	9	6	2	47
Temperature, high						1		1
Temperature, low	1							1
Thermal lift								0
No thermal lift		1				1		2
Total hazard category citations	4	10	10	8	9	8	2	51
Frequency per 100,000 flight-hours[a]	0.016	0.040	0.039	0.031	0.030	0.028	0.007	0.027
2006 goal	0.006							
2006 projection	0.010							
F. En route and terminal winds								
Unfavorable wind	2	2	1					5
Crosswind	5	7		1	1			14
Tail wind	6	7	2	6	2	7	3	33
High wind	2	7	5	2	1	3	2	22
Total hazard category citations	15	23	8	9	4	10	5	74
Frequency per 100,000 flight-hours[a]	0.060	0.092	0.031	0.035	0.013	0.034	0.018	0.040
2006 goal	0.015							
2006 projection	0.000							
G. Electrical hazards								
Lightning	1				1	1		3
Static discharge		1						1
Total hazard category citations	1	1	0	0	1	1	0	4
Frequency per 100,000 flight-hours[a]	0.004	0.004	0.000	0.000	0.003	0.003	0.000	0.002
2006 goal	0.0008							
2006 projection	0.0000							
H. Airborne solids hazards								
Sand/dust storm	1							1
Hail		1			1			2
Total hazard category citations	1	1	0	0	1	0	0	3
Frequency per 100,000 flight-hours[a]	0.004	0.004	0.000	0.000	0.003	0.000	0.000	0.002
2006 goal	0.001							
2006 projection	0.000							

[a]FAA estimated flight-hours per year:

1995	24,906,000
1996	24,881,000
1997	25,591,000
1998	25,518,000
1999	29,713,000
2000	29,057,000
2001	27,451,000

TABLE A-3. Part 121 (major commercial carrier) weather factor trend analysis: factor citations, all weather-related accidents

Hazard category and weather factor	1995	1996	1997	1998	1999	2000	2001	Total
All factors	11	13	20	10	10	16	10	89
Frequency per 100,000 departures[a]	0.130	0.158	0.194	0.091	0.088	0.140	0.099	0.126
2006 goal	0.029							
2006 projection	0.062							
A. Restricted visibility and ceiling hazards								
Fog		1						1
Low ceiling							1	1
Whiteout			1					1
Total hazard category citations	0	1	1	0	0	0	1	3
B. Precipitation (non-icing) hazards								
Rain		1	1					2
Snow			1					1
Drizzle/mist				1				1
Total hazard category citations	0	1	2	1	0	0	0	4
C. Icing conditions								
Icing conditions			1					
Total hazard category citations	0	0	1	0	0	0	0	1
D. Turbulence and convection hazards								
Turbulence (thunderstorms)		1	1	3			2	7
Turbulence, convection induced						1	1	2
Gusts						1		1
Wind shear	1					1		2
Mountain wave						1		1
Turbulence	5	1	3	1	5	6	3	24
Turbulence, clear air	3	7	7	2	3	2		24
Turbulence in clouds	1		2	1	1	3	2	10
Total hazard category citations	10	9	13	7	9	15	8	71
Frequency per 100,000 flight-hours[a]	0.118	0.109	0.126	0.064	0.080	0.131	0.079	0.100
2006 goal	0.023							
2006 projection	0.067							
E. Temperature and lift hazards								
Temperature, high		1					1	2
Total hazard category citations	0	1	0	0	0	0	1	2
F. En route and terminal winds								
Unfavorable wind	1			1				2
Crosswind		1	2			1		4
Total hazard category citations	1	1	2	1	0	1	0	6
H. Airborne solids hazards								
Hail				1				1
Total hazard category citations	0	0	0	1	0	0	0	1
I. Other			1		1			2
Total hazard category citations	0	0	1	0	1	0	0	2

[a]FAA estimates of departures by year:

1995	8,457,465
1996	8,228,810
1997	10,318,383
1998	10,979,762
1999	11,308,762
2000	11,457,812
2001	10,082,023
2002	10,400,000

TABLE A-4. Part 121 (major commercial carrier) weather factor trend analysis: factor citations, weather-related fatal accidents

Hazard category and weather factor	1995	1996	1997	1998	1999	2000	2001	Total
All factors	0	0	1	0	0	0	1	2
Frequency per 100,000 departures[a]	0.000	0.000	0.010	0.000	0.000	0.000	0.010	0.003
2006 goal	0.000							
A. Restricted visibility and ceiling hazards								
Fog								0
Low ceiling								0
Whiteout								0
Total hazard category citations	0	0	0	0	0	0	0	0
B. Precipitation (non-icing) hazards								
Rain								0
Snow								0
Drizzle/mist								0
Total hazard category citations	0	0	0	0	0	0	0	0
C. Icing conditions								
Icing conditions								
Total hazard category citations	0	0	0	0	0	0	0	0
D. Turbulence and convection hazards								
Turbulence (thunderstorms)								0
Turbulence, convection induced								0
Gusts								0
Wind shear								0
Mountain wave								0
Turbulence								0
Turbulence, clear air			1					1
Turbulence in clouds								0
Total hazard category citations	0	0	1	0	0	0	0	1
Frequency per 100,000 flight-hours[a]	0.000	0.000	0.010	0.000	0.000	0.000	0.000	0.001
2006 goal	0.000							
E. Temperature and lift hazards								
Temperature, high							1	1
Total hazard category citations	0	0	0	0	0	0	1	1
F. En route and terminal winds								
Unfavorable wind								0
Crosswind								0
Total hazard category citations	0	0	0	0	0	0	0	0
H. Airborne solids hazards								
Hail								0
Total hazard category citations	0	0	0	0	0	0	0	0
I. Other								0
Total hazard category citations	0	0	0	0	0	0	0	0

[a]FAA estimates of departures by year:

1995	8,457,465
1996	8,228,810
1997	10,318,383
1998	10,979,762
1999	11,308,762
2000	11,457,812
2001	10,082,023
2002	10,400,000

TABLE A-5. Part 135 (smaller aircraft in revenue service) weather factor trend analysis: factor citations, all weather-related accidents

Hazard category and weather factor	1995	1996	1997	1998	1999	2000	2001	Total
A. Restricted visibility and ceiling hazards								
Below approach/landing minimums							1	1
Clouds	2	1	3	2		2	2	12
Fog	5	9	6	3	1	3	1	28
Low ceiling	7	10	9	6	5	7	3	47
Obscuration	2	2	2					6
Whiteout	1	3	2	3	4	3	1	17
Total hazard category citations	17	25	22	14	10	15	8	111
Frequency per 100,000 flight-hours[a]	0.33	0.42	0.54	0.34	0.27	0.38	0.23	0.41
2006 goal	0.075							
2006 projection	0.18							
B. Precipitation (non-icing) hazards								
Rain	2		1	2		1	2	8
Snow	2	2	2	2	3	4	1	16
Drizzle/mist	1	1						2
Total hazard category citations	5	3	3	4	3	5	3	26
Frequency per 100,000 flight-hours[a]	0.10	0.05	0.07	0.10	0.08	0.13	0.09	0.077
2006 goal	0.015							
2006 projection	0.12							
C. Icing conditions								
Icing conditions	4	3	4	4	3	3	2	23
Freezing rain	1				1	1		3
Carburetor icing conditions			1			2		3
Total hazard category citations	5	3	5	4	4	6	2	29
Frequency per 100,000 flight-hours[a]	0.10	0.05	0.12	0.10	0.11	0.15	0.06	0.09
2006 goal	0.015							
2006 projection	0.12							
D. Turbulence and convection hazards								
Turbulence (thunderstorms)						1		1
Thunderstorm				1				1
Downdraft	2	1	5	2	3			13
Gusts	4	3	2	3	2		2	16
Variable wind	1	1					1	3
Turbulence					1	1	1	3
Turbulence in clouds	1							1
Turbulence (terrain induced)	1		2			1	1	5
Total hazard category citations	9	5	9	6	6	3	5	43
Frequency per 100,000 flight-hours[a]	0.18	0.08	0.22	0.14	0.16	0.08	0.14	0.13
2006 goal	0.026							
2006 projection	0.10							

(continued)

TABLE A-5. Part 135 (smaller aircraft in revenue service) weather factor trend analysis: factor citations, all weather-related accidents (continued)

Hazard category and weather factor	1995	1996	1997	1998	1999	2000	2001	Total
E. Temperature and lift hazards								
High density altitude	1		2	3	1	3		10
Temperature, low				1				1
Total hazard category citations	1	0	2	4	1	3	0	11
Frequency per 100,000 flight-hours[a]	0.02	0.00	0.05	0.10	0.03	0.08	0.00	0.03
2006 goal	0.002							
2006 projection	0.059							
F. En route and terminal winds								
Unfavorable wind	1	1	1		1	2		6
Crosswind		5	4	5	1	3	3	21
High wind	2	1	2	1	1		1	8
Tail wind		4	4	3	4	2	1	18
Total hazard category citations	3	11	11	9	7	7	5	53
Frequency per 100,000 flight-hours[a]	0.059	0.18	0.27	0.22	0.19	0.18	0.14	0.16
2006 goal	0.024							
2006 projection	0.23							
G. Electrical hazards								
Lightning	1							1
Total hazard category citations	1	0	0	0	0	0	0	1
Frequency per 100,000 flight-hours[a]	0.020	0.000	0.000	0.000	0.000	0.000	0.000	0.003
2006 goal	0.002							
2006 projection	0.00							

[a]FAA estimated flight-hours per year:

1995	5,113,866
1996	5,976,755
1997	4,080,764
1998	4,155,670
1999	3,640,731
2000	3,922,535
2001	3,476,432

TABLE A-6. Part 135 (smaller aircraft in revenue service) weather factor trend analysis: factor citations, weather-related fatal accidents

Hazard category and weather factor	1995	1996	1997	1998	1999	2000	2001	Total
A. Restricted visibility and ceiling hazards								
Below approach/landing minimums								0
Clouds	2	1	3	2		1	1	10
Fog	3	2	2	2	1	2		12
Low ceiling	6	5	4	1	2	5	3	26
Obscuration	2	1						3
Whiteout			1		1	1	1	4
Total hazard category citations	13	9	10	5	4	9	5	55
Frequency per 100,000 flight-hours[a]	0.25	0.15	0.25	0.12	0.11	0.23	0.14	0.181
2006 goal	0.04							
2006 projection	0.09							
B. Precipitation (non-icing) hazards								
Rain	1			1		1		3
Snow	1			2	1	1	1	6
Drizzle/mist		1						1
Total hazard category citations	2	1	0	3	1	2	1	10
Frequency per 100,000 flight-hours[a]	0.04	0.02	0.00	0.07	0.03	0.05	0.03	0.033
2006 goal	0.006							
2006 projection	0.05							
C. Icing conditions								
Icing conditions	1	1	2	2	1	2	2	11
Freezing rain								0
Carburetor icing conditions								
Total hazard category citations	1	1	2	2	1	2	2	11
Frequency per 100,000 flight-hours[a]	0.02	0.02	0.05	0.05	0.03	0.05	0.06	0.036
2006 goal	0.004							
2006 projection	0.08							
D. Turbulence and convection hazards								
Turbulence (thunderstorms)						1		1
Thunderstorm								0
Downdraft	1		1					2
Gusts		1						1
Variable wind								0
Turbulence								0
Turbulence in clouds	1							1
Turbulence (terrain induced)	1		1					2
Total hazard category citations	3	1	2	0	0	1	0	7
Frequency per 100,000 flight-hours[a]	0.06	0.02	0.05	0.00	0.00	0.03	0.00	0.023
2006 goal	0.008							
2006 projection	0.00							

(continued)

TABLE A-6. Part 135 (smaller aircraft in revenue service) weather factor trend analysis: factor citations, weather-related fatal accidents (continued)

Hazard category and weather factor	1995	1996	1997	1998	1999	2000	2001	Total
E. Temperature and lift hazards								
High density altitude	1				1			2
Temperature, low				1				1
Total hazard category citations	1	0	0	1	1	0	0	3
Frequency per 100,000 flight-hours[a]	0.02	0.00	0.00	0.02	0.03	0.00	0.00	0.01
2006 goal	0.0020							
2006 projection	0.0012							
F. En route and terminal winds								
Unfavorable wind								0
Crosswind								0
High wind	1	1	1	1				4
Tail wind		1						1
Total hazard category citations	1	2	1	1	0	0	0	5
Frequency per 100,000 flight-hours[a]	0.02	0.03	0.02	0.02	0.00	0.00	0.00	0.02
2006 goal	0.0053							
2006 projection	0.0000							
G. Electrical hazards								
Lightning								0
Total hazard category citations	0	0	0	0	0	0	0	0
Frequency per 100,000 flight-hours[a]	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000
2006 goal	0.000							
2006 projection	0.00							

[a]FAA estimated flight-hours per year:

1995	5,113,866
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1997	4,080,764
1998	4,155,670
1999	3,640,731
2000	3,922,535
2001	3,476,432

Appendix B

Acronyms and Abbreviations

ACMS	Aircraft Condition Monitoring System
ADAS	AWOS Data Acquisition System
ADDS	Aviation Digital Data Service
ADS-B	Automatic Dependent Surveillance–Broadcast
ADWSA	Automatic Delivery of Wind Shear Alerts
AFWA	Air Force Weather Agency
AHAS	Airborne Hazard Awareness System
AIP	Aircraft Icing Product
ALDA	Airborne LIDAR Detection Algorithm
AMS	Automated Meteorological System
AOC	Aviation Operations Course
AOPA	Aircraft Owners and Pilots Association
AOS	Automated Observing System
APWE	Aviation Pilot Weather Education
ARL	Air Resources Laboratory
ARNAV	ARNAV Systems, Inc.
ARS	Air Traffic Service Requirements Service (FAA)
ASAP	Advanced Satellite Aviation Products
ASF	Air Safety Foundation
ASOS	Automated Surface Observing System
ASR-9	Airport Surveillance Radar–9
ATB	Terminal Business Service (FAA)
ATC	air traffic control
ATLAS	Aircraft Total Lightning Advisory System
AUA	Office of Air Traffic Systems Development (FAA)
AvSP	Aviation Safety Program (NASA)
AWARE	Aviation Weather Awareness and Reporting Enhancement
AWC	Aviation Weather Center (NOAA)
AWH	Aviation Weather Hazards
AWHCS	Aviation Weather Hazard Characterization System
AWIN	Aviation Weather Information
AWIPS	Advanced Weather Interactive Processing System
AWOS	Automated Weather Observing System
AWRP	Aviation Weather Research Program
C&V	Ceiling and Visibility
CA	Circulation Algorithm
CAPS	Center for Analysis and Prediction of Storms (University of Oklahoma)
CCFP	Collaborative Convective Forecast Product
CDFS II	Cloud Depiction and Forecast System
CDMNET	Collaborative Decision Making Net
CIP	Current Icing Potential
CIWS	Corridor Integrated Weather System
COMET	Cooperative Program for Operational Meteorology, Education and Training
CRA	cooperative research agreement
CRREL	Cold Regions Research and Engineering Laboratory (U.S. Army)
DA	Divert Alerts
DCAFS	Dallas-Fort Worth Collaborative Aviation Forecast Study
DLAC	Distance Learning Aviation Course
DOD	Department of Defense
E&T	Education and Training Program
EAA	Experimental Aircraft Association
EDR	eddy dissipation rate
ERDC	Engineer Research and Development Command (U.S. Army)
ESE	Earth Science Enterprise (NASA)
ESID	Electrical Storm Identification Device
EWINS	Enhanced Weather Information System Training
EWxR	Enhanced Weather Radar
FAA	Federal Aviation Administration
FBWTG	FAA Bulk Weather Telecommunications Gateway
FDI	Forecasting for De-Icing
FFP	Fog Forecasting Process
FIP	Forecast Icing Potential
FIS-B	Flight Information Services–Broadcast
FISDL	Flight Information Services Data Link
FSL	Forecast Systems Laboratory (NOAA)
FY	fiscal year
GAF	Graphical Area Forecast
GIFTS	Geosynchronous Imaging Fourier Transform Spectrometer
GLDI	Global Lightning Data Integration
GOES	geostationary operational environmental satellite

GPS	global positioning system
GRC	Glenn Research Center (NASA)
GRIDS	Ground-Based Remote Icing Detection System
GTG	Graphical Turbulence Guidance
GTWAPS	Global Theater Weather Analysis and Prediction System
GWIS	Global Weather Information System
HYSPLIT	Hybrid Single Particle Lagrangian Integrated Trajectories
IFR	instrument flight rules
IHAS	Integrated Hazard Avoidance System
IMC	instrument meteorological conditions
IMETS	Integrated Meteorological System
IP	Internet Protocol
IRP	Icing Research Program (U.S. Army)
ITA	In-Situ Turbulence Algorithm
ITWS	Integrated Terminal Weather System
JAWS	Juneau Airport Wind System
LCP	Low Cloud Product
LIDAR	Light Detection and Ranging
LLWAS	Low Level Windshear Alert System
LLWAS-NE	Low Level Windshear Alert System – Network Expansion
LPATS	Lightning Position and Tracking System
MDCRS	Meteorological Data Collection and Reporting System
METAR	aviation routine weather report
METMF (R)	Marine Corps Meteorological Mobile Facility Replacement
METOC	Meteorology and Oceanography
MIAWS	Medium Intensity Airport Weather System
MIDDS-T	Meteorological Integrated Data Display System – Tactical
MIT	Massachusetts Institute of Technology
MMCR	Millimeter Cloud Radar
MMS-P	Meteorological Measuring Set – Profiler
MRC	Multi-Radar Composites
MRS	Mini Rawinsonde System
MSC	Meteorological Services of Canada
MSFS	Marine Stratus Forecast System
MWAVE	Mountain Wave
MWFM	Mountain Wave Forecast Model
NAAPS	Navy Aerosol Analysis and Prediction System
NAS	National Airspace System
NASA	National Aeronautics and Space Administration
NATA	National Air Transportation Association
NAW/PC	National Aviation Weather Program Council
NCAR	National Center for Atmospheric Research
NCEP	National Centers for Environmental Prediction (NOAA)
NCV	National Ceiling and Visibility
NCWF	National Convective Weather Forecast
NESDIS	National Environmental Satellite, Data, and Information Service (NOAA)
NEXRAD	Next Generation Weather Radar (WSR 88D)
NFWB	Navy Flight Weather Briefer
NITES	Naval Integrated Environmental Subsystem
NLDN	National Lightning Detection Network
NMOC	Naval Meteorology and Oceanography Command (U.S. Navy)
NOAA	National Oceanic and Atmospheric Administration
NOTAM	notice to airmen
NPOESS	National Polar-orbiting Operational Environmental Satellite System
NSDS-E	Naval Satellite Display System – Enhanced
NSF	National Science Foundation
NTDA	NEXRAD Turbulence Detection Algorithm
NTFS	New Tactical Forecast System
NTSB	National Transportation Safety Board
NWA	National Weather Association
NWS	National Weather Service (NOAA)
NWSTC	National Weather Service Training Center (NOAA)
OACD	Oceanic Automated Convective Diagnosis Product
OACN	Oceanic Automated Convective Nowcast Product
OAR	Office of Oceanic and Atmospheric Research (NOAA)
OASIS	Operational and Supportability Implementation System
OCTH	Oceanic Cloud Top Height Product
OFCM	Office of the Federal Coordinator for Meteorological Services and Supporting Research
OITFA	Oceanic Integrated Turbulence Forecast Algorithm
OPS II	Operational Weather Squadron Production System, Phase II
OPUP	Open Principal User Processor
PA	Polarization Algorithm
PCIS	PC-based Icing Simulator
PIREP	pilot report
PTI	Pilot Training Initiative
PUFF	Volcanic Ash Dispersion Model
QTP	Qualification Training Packages
R&D	research and development
RADAR	Radio Detection and Ranging
RAWS	Remote Automated Weather Sensor
RCWF	Regional Convective Weather Forecast
RUC	Rapid Update Cycle
RVR	Runway Visual Range
SBID	Satellite-Based Icing Detection
S-DARS	Satellite Digital Audio Radio Service
SIGMET	Significant Meteorological Advisory
SMOOS (R)	Shipboard Meteorological and Oceanographic Observing System Replacement

SVS	synthetic vision systems
SWAP	Severe Weather Avoidance Program
SWIS	Satellite Weather Information System
SWR	Supplemental Weather Radar
TAF	Terminal Aerodrome Forecast
TAM	Tactical Area Met program
TAMDAR	Tropospheric Airborne Meteorological Data Reporting
TCV	Terminal Ceiling and Visibility
TCWF	Terminal Convective Weather Forecast
TDWR	Terminal Doppler Weather Radar
TEDS	Tactical Environmental Data Services
TEP	Tactical Environmental Processor
TIS-B	Traffic Information Service–Broadcast
TMOS	Tactical Meteorological Observing System
TPS	Turbulence Plot System
TWR	Tactical Weather Radar
UAT	Universal Access Transceiver
UCAR	University Corporation for Atmospheric Research
VAA	Volcanic Ash Avoidance
VAFTAD	Volcanic Ash Forecast Transport and Dispersion Model
VAG	Volcanic Ash Graphic
VAP	Volcanic Ash Product
VAW	Volcanic Ash Warning
VDLM2	VHF Data Link Mode 2
VHF	very high frequency
WARP	Weather and Radar Processor
WebASD	Web-based Aircraft Situation Display
WGPP	Wind Gust Potential Product
WINCOMM	Weather Information Communications
WINN	Weather Information Network
WMSCR	Weather Message Switching Center Replacement
WRF	Weather Research and Forecasting
WSDDM	Weather Support to De-Icing Decision Making
WSP	Weather System Processor (ASR-9)
WSR 88D	Weather Surveillance Radar 1988 Doppler (NEXRAD)
WVSS	Water Vapor Sensing System
WxAP	Weather Accident Prevention Program (NASA)
WxITC	Weather-in-the-Cockpit